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THEORY OF NONLINEAR PROCESSES

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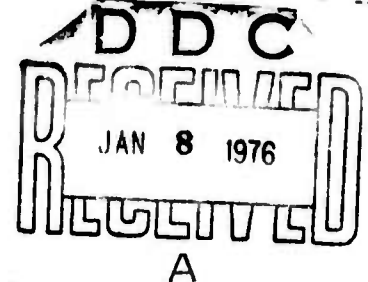
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FINAL TECHNICAL REPORT

THEORY OF NONLINEAR PROCESSES ✓

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The subject matter of this research has been quite diverse. It is naturally divided into activities of two periods, the earlier of which (1967-69) was concerned with mathematical models of biophysical phenomenon, and the later (1970-74) with mathematical modeling of non linear processes especially those concerned with quantum optics and non linear wave propagation. The results of the research over the seven years of the contract are recorded in the published papers named on the publication list. Reprints of these papers are included.

The topics investigated in the early biophysical phase were:

- 1) Statistical mechanics of macromolecules especially as related to DNA denaturation processes
- 2) Electrostatics of models of lipid films and interfaces between fluid layers
- 3) Modeling of exciton migration in photosynthetic units

A transition from the original program on biophysical processes into the new program on nonlinear process was made in our research on nonlinear models of population growth and competition. The equations which govern these processes are similar to those which occur in certain models of laser dynamics.

The topics studied in the program on nonlinear process included:

- a) Model systems in quantum optics
- b) Nonlinear wave propagation in crystal lattices
- c) Basic studies in nonlinear dynamics
- d) Wave propagation in a Navier-Stokes fluid

In our early work on nonlinear processes, emphasis was placed on the construction of solvable nonlinear models for phenomenon of interest. We were successful in finding a number of models whose mathematical would be discussed in great detail without making uncontrolled approximation and from these we enlarged our intuition about nonlinear phenomenon in general.

Our more recent work has emphasized the development of novel perturbation methods. In these methods we have been able to avoid the secular term problem and those of small denominators which have been traditional difficulties in older procedures.

Publications Supported by the Contract

(N00014-67-A-0398)

1968

N. S. Goel

Relaxation Kinetics of Denaturation of RNA
Biopolymers 6, 55 (1968)

N. S. Goel, E. W. Montroll

Denaturation and Renaturation of DNA. II. Possible use of Synthetic
Periodic Copolymers to Establish Model Parameters
Biopolymers 6, 731 (1968)

N. S. Goel, N. Fukuda, R. Rein

A Semi-empirical Analysis of the Melting Curves of Synthetic DNA
Molecules and the Calculation of the Stacking and Pairing Energies and
Entropies in DNA

J. Theoret. Biol. 18, 350 (1968)

E. W. Montroll, Lee-Po Yu

Analysis of Assemblies with Large Defect Concentrations with Special
Application to Theory of Denaturation of Copolymeric DNA
Localized Excitations in Solids (Plenum Press, N.Y., 1968), p.745

V. S. Vaidhyanathan, N. S. Goel

Stability of Lipid Films in Aqueous Electrolyte Media: Electrostatic
Interactions

J. Theoret. Biol. 21, 331 (1968)

1969

F. P. Buff, N. S. Goel

Electrostatics of Diffuse Anisotropic Interfaces. I. Planar Layer
Model

J. Chem. Phys. 51, 4983 (1969)

F. P. Buff, N. S. Goel

Electrostatics of Diffuse Anisotropic Interfaces. II. Effects of Long-
Range Diffuseness

J. Chem. Phys. 51, 5363 (1969)

R. A. Elliott, K. Lakatos, R. S. Knox

The Effect of Lattice Vibrations on Trap-Limited Exciton Lifetimes

J. Statistical Phys. 1, 253 (1969)

N. S. Goel, S. C. Maitra

On the Existence of Independently Melting Subunits in a Copolymeric DNA
and their Statistical Distribution

J. Theoret. Biol. 23, 87 (1969)

K. Lakatos

Statistics of a Two-dimensional Gas of Long Thin Rods

J. Chem. Phys. 50, 3822 (1969)

R. G. Mills, C. A. Hurst
Generalized Triangular Ising Lattice
J. Math. Phys. 10, 1531 (1969)

E. W. Montroll
Random Walks on Lattices. III. Calculation of First-Passage Times
with Application to Exciton Trapping on Photosynthetic Units
J. Math. Phys. 10, 753 (1969)

1970

F. A. Blood, Jr.
Approximate Calculations for the Two-dimensional Ising Model
J. Statistical Phys. 2, 301 (1970)

R. C. t. DaCosta
Nonlinear Light Propagation in Resonant Medium and Causality
J. Math. Phys. 11, 2799 (1970)

N. S. Goel, F. P. Buff
On Some Relations between the Solutions and the Parameters of Second-
Order Linear Differential Equations
J. Math. Phys. 11, 508 (1970)

N. S. Goel, A. G. Leith
Self-Sorting of Anisotropic Cells
J. Theor. Biol. 28, 469 (1970)

R. G. J. Mills, E. W. Montroll
Quantum Theory on a Network: II. A Solvable Model which May Have
Several Bound States Per Node Point
J. Math. Phys. 11, 2525 (1970)

E. W. Montroll
Quantum Theory on a Network: I. A Solvable Model Whose Wavefunctions are
Elementary Functions
J. Math. Phys. 11, 635 (1970)

C. A. Radin
Approach to Equilibrium in a Simple Model
J. Math. Phys. 11, 2945 (1970)

1971

N. S. Goel, S. C. Maitra, E. W. Montroll
On the Volterra and Other Nonlinear Models of Interacting Populations
Rev. Mod. Phys. 43, 231 (1971)

S. Okubo, A. Isihara
Some Considerations on Entropy Change
J. Math. Phys. 12, 2498 (1971)

M. Wadati, A. Isihara
Short-distance Correlations of Charged Particles
Phys. Rev. A 4, 344 (1971)

1972

M. Altarelli, D. L. Dexter, H. M. Nussenzveig, D. Y. Smith
Superconvergence and Sum Rules for the Optical Constants
Phys. Rev. B 6, 4502 (1972)

A. Isihara, M. Wadati
Quantum Effects on the Electron Correlation Function
Physica 57, 237 (1972)

E. W. Montroll
Some Statistical Aspects of the Theory of Interacting Species
Some Mathematical Problems in Biology, vol. IV (Am. Math. Soc.,
Providence, R.I., 1972), p.101

E. W. Montroll
On Coupled Rate Equations with Quadratic Nonlinearities
Proc. Nat. Acad. Sci. USA 69, 2532 (1972)

E. W. Montroll
Nonlinear Rate Processes, Especially Those Involving Competitive
Processes
Statistical Mechanics: New Concepts, New Problems, New Applications
(ed. by S. A. Rice, Karl F. Freed, J. C. Light) (U of Chicago Press,
1972) p.69

H. M. Nussenzveig
Some Recent Developments in Quantum Optics
Proc. IV Brazilian Symposium in Theoretical Physics, Rio de Janeiro,
1972, p.53

S. Okubo, A. Isihara
Inequality for Convex Functions in Quantum Statistical Mechanics
Physica 59, 228 (1972)

M. Wadati, A. Isihara
Theory of Liquid Crystals
Molec. Crystals & Liquid Crystals 17, 95 (1972)

1973

F. T. Hioe
Phase Transitions in Some Generalized Dicke Models of Superradiance
Phys. Rev. A 8, 1440 (1973)

Y. K. Wang
Master Equation of a Mean-Field-Model Ferromagnet
Phys. Rev. B 8, 5199 (1973)

Y. K. Wang, F. T. Hioe
Phase Transition in the Dicke Model of Superradiance
Phys. Rev. A 7, 831 (1973)

1974

R. H. G. Helleman, E. W. Montroll
On a Nonlinear Perturbation Theory without Secular Terms
Physica 74, 22 (1974)

F. T. Hioe
An Approach to the Study of Quantum Systems
J. Math. Phys. 15, 445 (1974)

F. T. Hioe
Coherent States and Lie Algebras
J. Math. Phys. 15, 1174 (1974)

F. T. Hioe, C. Domb
Group Theory, Markov Chains, and Excluded Volume Effect in Polymers
J. Statistical Phys. 10, 183 (1974)

E. W. Montroll
Propagation of Waves in Nonlinear Lattices
Lecture Notes in Physics (Schieve and Turner, eds.), vol. 28 (Springer, Berlin, 1974), p. 28.

1975

F. T. Hioe, J. H. Eberly
Stimulated and Spontaneous Radiative Shifts in a Two-Level System
Phys. Rev. A 11, 1358 (1975).